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CONTROL BY STIMULUS FEATURES DURING FADING[1]

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Sixteen children were given four successive circle-size discrimination problems with luminance as the fading stimulus. Children who were first presented with a difficult size discrimination failed to acquire this discrimination. Those who first received an easy discrimination learned the difficult discrimination. At the end of each 10-trial block, two probe stimuli were presented to monitor any shift in control from luminance to size. One probe was the same size as the positive stimulus but of different luminance; the other was the same luminance but of different size. If, in the course of fading, size and luminance both controlled responding, fading was successful. If luminance alone controlled responding until the end of fading, the size discrimination was not established. Dual control, and thus successful fading, resulted when the target stimuli were very discriminable, or when the target stimuli were subtly different provided that previous fading series had first established less subtle discriminations.

Key words: stimulus control, fading, errorless discrimination learning, transfer of stimulus control, window press, children

In recent years there have been several demonstrations of discriminations acquired without errors. These results were not predicted from the prevailing theoretical conception that extinction was necessary to form a discrimination. Interest was largely focused on the fact that errorless discrimination learning was possible, on how errorless learning differed from errorful learning in various byproducts, and on the contributions that an analysis of errorless learning might make to discrimination learning theories that do not include interacting gradients of excitation and inhibition (Terrace, 1972). What has received relatively less attention, however, is a detailed procedural analysis to determine the necessary and sufficient conditions for the establishment of errorless discrimination learning.

The fading procedures used in establishing errorless discriminations are similar in some respects to procedures used to investigate selective attention to compound stimuli. Logically, before the fading cue is removed, the fading cue and target feature form a compound stimulus. Either feature is sufficient to control responding; thus, attention may be shared or selective. In selective attention studies (e.g., Chase & Heinemann, 1972; Johnson & Cumming, 1968; vom Saal & Jenkins, 1970), control by one feature of a compound stimulus in certain instances prevents or blocks the acquisition of control by other features present in the compound stimulus; in other instances, however, control by both features is acquired during compound stimulus training. Thus, there are interesting similarities in procedures for fading and selective attention and in behavioral outcomes.

Selective attention studies with redundant compound stimuli have suggested certain relations among various stimulus features; for example, pigeons are more likely to respond on the basis of visual cues rather than auditory cues (Miles & Jenkins, 1973); monkeys are more likely to respond on the basis of color rather than form or size (Warren, 1953). But

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these assertions must be qualified because it has also been shown that cue selection can be altered by changes in discriminability of the available stimulus features (Gilner, Pick, Pick, & Hales, 1969; Imai & Garner, 1965; Miles & Jenkins, 1973) or by prior training with the feature less likely to gain control (Chase & Heinemann, 1972).

Previous studies with sea lions (Schusterman, 1967) and with retarded children (Touchette, 1971) measured stimulus control during successful fading series and suggested that shifts in stimulus control occur. The target feature, previously ineffective in controlling differential responding, becomes effective as demonstrated by the lack of errors when the fading cue is eliminated. In a similar study with pigeons, Fields, Bruno, and Keller (1976) demonstrated that, during a successful fading series, the target feature first gains control while the fading cue still controls responding. However, responding to one of the probes used to measure the controlling feature may have been affected by an earlier history of extinction in the presence of the same stimulus compound. Furthermore, the Fields et al. study examined stimulus control shifts only during a successful fading series. Terrace (1963) with pigeons and Cohen (1968) with children both found that a fading series which was successful for one type of stimulus was unsuccessful with other stimuli. Why fading should work for some target stimuli and not others is as yet an unanswered question.

To investigate this question, the present study measured stimulus control during successful and unsuccessful fading and analyzed factors influential in affecting the type of stimulus control shown throughout fading. One possible factor, suggested by research in selective attention, is discriminability of the stimulus features. In a fading series, changes in discriminability may occur. As the fading cue becomes less discriminable, the target cue, if highly discriminable, is more likely to become effective in controlling differential responding. But if the fading and target features are both low in discriminability, which may obtain at the final stages of a fading series, the fading cue controls until it is removed. Then errors occur.

This experiment analyzed the acquisition in young children of circle-size discriminations, using a luminance fading series. The effect of changes in luminance between S+ and S− upon the acquisition of control by size was evaluated for three size discrimination problems ranging in difficulty. Three sequences of size discriminations were investigated to determine if discriminability of the target feature is affected by the learner's mastery of easier discriminations along that dimension.

METHOD

Subjects

Sixteen children, aged 6 to 7 yr, from neighboring schools served.

Apparatus

A 20- by 15-cm display panel containing a single response key was placed on a child's table directly in front of a child's chair. The key, 2.5 cm square, was mounted in the center of the panel. The key could be illuminated by white circles with diameters ranging from 5 mm to 14 mm on a black background. These circles were projected by a 28-V inline projector (Industrial Electronic Engineers, Inc., Series 1820L). The luminance and, to a slight extent, the spectral composition of a particular circle were controlled by resistors inserted into the projector circuit. The luminance values ranged from approximately −1.5 log ft. L., the dimmest, to +1.28 log ft. L., the brightest. Luminance measurements were made with a Salford Electrical Instruments photometer. The experimental room throughout each session was illuminated at −1.7 log ft. L. by means of a tungsten lamp containing a 60-W bulb and overhead fluorescent lights controlled by a rheostat. A Grason-Stadler marble dispenser was mounted on the left side of the panel, and a door chime was mounted under the table.

Reinforcement consisted of a marble dispensed into a long tube and a ringing of the chime. After each session, marbles were exchanged for M&M's. At the end of the last size discrimination session, the child took home a small toy that had been selected at the beginning of training.

Stimulus changes, response recording, and reinforcement contingencies were automatically controlled by electromechanical equipment.

Procedure

Preliminary training. The child was brought to the experimental room and seated in front of the stimulus panel on which S+ appeared. These instructions were given: "Press this circle. Sometimes when you press this circle, a bell will ring and a marble will drop down this tube. You get one M&M for every two marbles."

After each circle press in this preliminary session, an intertrial interval (ITI) occurred during which the key was dark. After the first response, the ITI was .5 sec. Over the next seven trials, the ITI increased in .5-sec steps until ITI was 4 sec. Any response during ITI reset a timer which delayed the onset of S+ by the value of ITI during which the response was made.

An intermittent schedule of reinforcement of responses to S+ was introduced during this session to minimize the disruptive effects of unreinforced probe trials to be used in later sessions. Each circle press was reinforced for the first 20 S+ trials. Responses on the next 12 S+ trials were reinforced with a probability of .92 (11 of the 12 trials); responses on the next 12 S+ trials were reinforced with a probability of .83 (10 of the 12 trials); and, finally, over the last 24 S+ trials, responses were reinforced with a probability of .75 (18 of the 24 trials).

A child who responded during each S+ and did not respond during any ITI on the last 12 trials was considered to have achieved criterion. If criterion was not met, the preliminary session continued until 12 trials elapsed with responses to each S+ and with no responses during ITI.

Size discrimination training. Size discrimination training began on the next session. The following instructions were given: "Do you remember the circle you saw yesterday? Today you will see yesterday's circle and some other circles, but only press yesterday's circle. Today you will get an M&M for every marble that comes down. Remember some are different, only press yesterday's circle. Ready?" On the following days, the child was told: "Remember, some are different, only press yesterday's circle. Ready?" Each training session consisted of successive presentations of 70 trials. They included 30 S+ trials, 30 S− trials, and 10 probe trials. S+ trials and S− trials were presented in six 10-trial blocks, each with five S+ and five S− trials randomly presented except that no more than three trials of either type occurred in succession. Each S+ trial was terminated either by a response which turned off the stimulus light and, with a .75 probability, produced a marble and sounded the chime, or by a 5-sec interval without a response. After a 4-sec ITI, the next trial began unless a response had occurred during ITI. Each response during ITI reset a timer which delayed the onset of the next trial by 4 sec. Each S− trial ended after its specified duration if no response occurred. In the instances of a response during S−, the timer reset so that the trial terminated only after the required interval (See Table 1) passed without a response. Upon the termination of S−, an ITI of 4 sec followed before the onset of the next trial.

Probe stimuli were used to assess control by the size and luminance cues. Figure 1 presents the size and luminance of S+, S−, and probe stimuli for each of the three problems. One type of probe, the target probe, was a small bright circle with luminance equal to S+ at +1.28 log ft. L. and size equal to the S− of the particular problem, either 5 mm, 10 mm, or 12 mm. The other type of probe, the fading probe, was a circle as large as S+ that took on the luminance value of S− at five points along the fading series, indicated by the superscript "1" in Table 1. Ten probe trials occurred during each session, five of each type. After every 10th trial, each type of probe was presented once with the order randomly chosen. A probe trial was terminated either by a response or by the end of a 5-sec period without a response. No reinforcement was given on probes. Ten criterion trials, with S+ and S− at full luminance and differing only in size, followed the 10th probe trial. If the subjects responded to each S+ and did not respond to each S− on criterion, the size discrimination had been established.

In each session, the same fading series was used. The luminance of the S− increased over 25 S− trials from −1.5 log ft. L. to +1.28 log ft. L. Table 1 presents the luminance values of S− along the fading series. At the end of the fading series, both S+ and S− were at +1.28 log ft. L.; size was the only distinguishing feature between S+ and S−. As shown in Table 1, within each block during which the S− was undergoing changes in lumi-

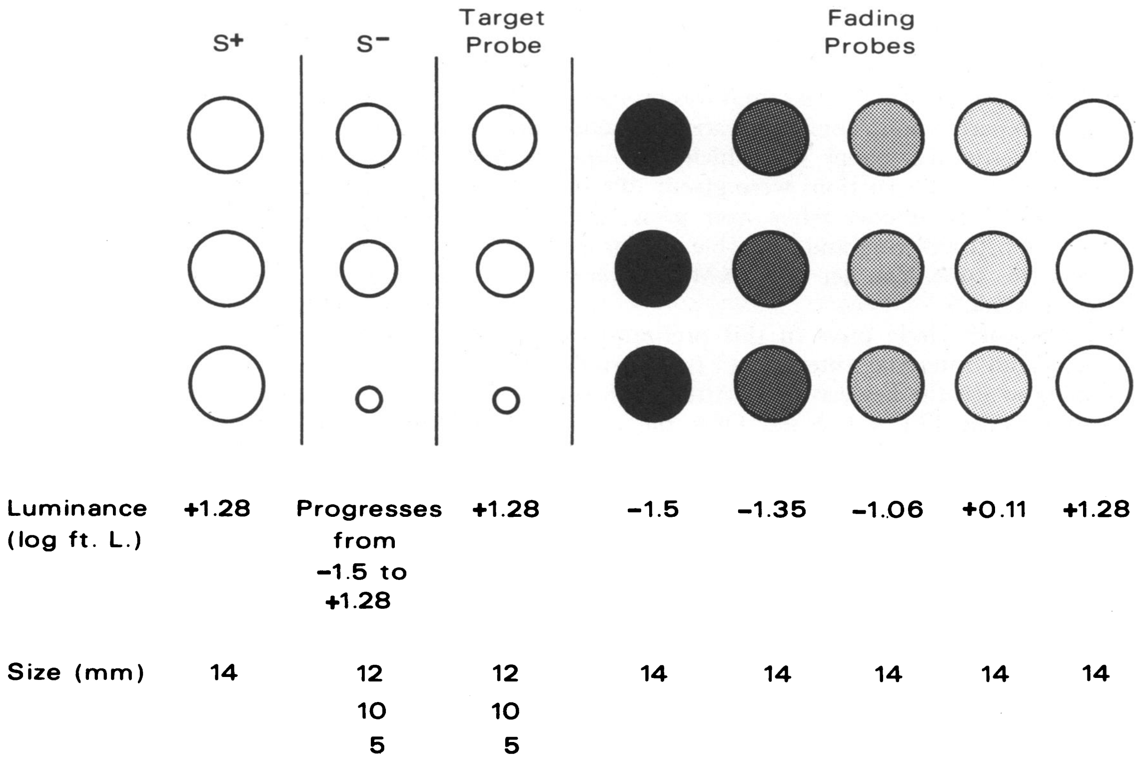

Figure 1. Size and luminance values of S+, S— and probes for each of three successive discrimination problems. The rows describe the different problems; columns show stimuli used within each problem.

nance, the duration of S— increased over the five trials from 3 to 5 sec. This gradual lengthening of the S— within a block was used as an additional means of preventing errors.

Each subject received four size discrimination sessions. In each session, S+ was a circle 14 mm in diameter with a luminance of +1.28 log ft. L. In different problems, S— was a circle 5 mm in diameter (the easy problem), 10 mm in diameter (the intermediate problem), or 12 mm in diameter (the difficult problem).

Table 1

Duration (sec) and luminance values (log ft L) of S— during fading in successive 5-trial blocks.

Duration, (sec)	*Blocks*[2]				
	1	*2*	*3*	*4*	*5*
3.0	bulb off	−1.50	−1.35	−1.06	+ .11
3.5	−1.50	−1.35	−1.21	− .77	+ .40
4.0	−1.50	−1.35	−1.21	− .48	+ .69
4.5	−1.50	−1.35	−1.06	− .18	+ .99
5.0	−1.50[1]	−1.35[1]	−1.06[1]	+ .11[1]	+1.28[1]

[1]Value used in fading probe.
[2]In Criterion testing, the duration of S— was 5.0 and luminance was +1.28.

Three sequences of problems were investigated. Some subjects were given the difficult problem first, then the easy and intermediate problems, and finally a second session on the difficult problem. This is called the Difficult/Gradual Progression Condition. Other subjects received the easy problem and the intermediate problem before two sessions on the difficult problem. This condition is called the Gradual Progression Condition. Other subjects were given the difficult problem in each of the four sessions. This is called the Difficult Condition. On the fourth session, subjects in all conditions received the difficult problem; their performance was expected to reflect their experimental histories, with only subjects in the Difficult/Gradual Progression and Gradual Progression Conditions responding differentially on the target stimuli at criterion when the fading cue was removed.

RESULTS

Preliminary Session

The preliminary session presented only S+ trials followed by ITI. After a nonreinforced response on the intermittent schedule, some subjects responded during the following ITI when the key was dark. The preliminary session was then extended until 12 trials occurred with a response to each S+ and no responding during ITI. The mean number of intertrial responses was 3.4, 2.5, and 2.6 for the Gradual Progression, Difficult/Gradual Progression, and Difficult Condition, respectively. The difference in group means was not reliable at the .05 level of confidence (Kruskal-Wallis one-way analysis of variance).

Size Discrimination Sessions

Individual data for the four size discrimination problems given to each subject are shown in Figure 2. The individual curves present performance during the programmed series, on criterion trials, and on probe trials. The number of trials on which an error occurred is plotted along the ordinate for each size discrimination problem. An error is defined as a response to S− or the lack of a response to S+ within 5 sec of its onset. Because S− was not terminated until a required number of sec had elapsed without a response, multiple errors on an S− trial were possible. (Multiple errors occurred relatively infrequently, however, and will be presented later in Table 2.) To simplify the discussion in the text that follows, a trial with errors will be referred to simply as an "error."

The subjects were randomly assigned to one of three groups, each with a different sequence of size problems. The sequence given each subject is indicated by the numbers in parentheses. Problems are identified by the difference in mm of S+ and S− circle diameters; thus, the easy problem is identified on the figures as "9-mm difference," the intermediate problem as "4-mm difference," and the difficult problem as "2-mm difference." The abscissa presents trial-by-trial performance, labeled according to trial blocks of 10 trials each. Each block contained five S+ and S− trials. Criterion trials occurred in Block 6. The same sequence of S+ and S− trials was given to each subject on each of the four size problems. For each trial, the data line moved one step horizontally. If no errors occurred, the data points formed a straight horizontal line. Each error, however, moved the data line one step upward. The amount and location of deviation from the horizontal indicate the number and location of errors within the fading series on criterion trials.

Between each block of 10 trials (indicated by a triangle on the abscissa) a set of two probe trials occurred in random order: a target probe as bright as S+ but only as large as the S− of the particular problem, and a fading probe as large as S+ but only as bright as the preceding S− in the fading series (see Figure 1). Performance on the two probes, considered as a pair or set, indicated the nature of the stimulus control at five points along the fading series for each size discrimination problem. By the fifth probe set at the end of the fading series, the fading probe was also as bright as S+. Thus the fifth probe set contained criterial probes in that the target probe was the same as the criterion S− and the fading probe was the same as the criterion S+. Because the luminance cue at this point in the series had been completely faded, no control by luminance was possible.

Stimulus control was measured through use of the probe data. Control by luminance alone was indicated when the subject responded on the target probe and did not respond on the fading probe. Control by size alone was indicated when the subject did not respond on the target probe but responded on the fading probe. Dual control by luminance and size was indicated when the subject did not respond on either probe. Control by neither luminance nor size was indicated when the subject responded on both probes. The probe data were only meaningful, however, if responding on S+ and S− was essentially errorless.

Difficult condition. The records of five subjects given four sessions on the most difficult problem (2 mm difference in S+ and S− diameter) are in the upper left panel of Figure 2. All five subjects performed nearly errorlessly until the fifth trial block of each session when the luminance cue became very subtle. Three of the five subjects, Carol, Jean, and Arletha, made extensive errors on all four presentations of the criterion trials in Block 6. Two subjects, Matt H. and Susie, also made errors on criterion trials, but their performance showed some evidence of control by size.

The probe data for the three nonlearners, Carol, Jean, and Arletha, revealed almost exclusive control by luminance through the fourth probe set. Then, as the luminance cue

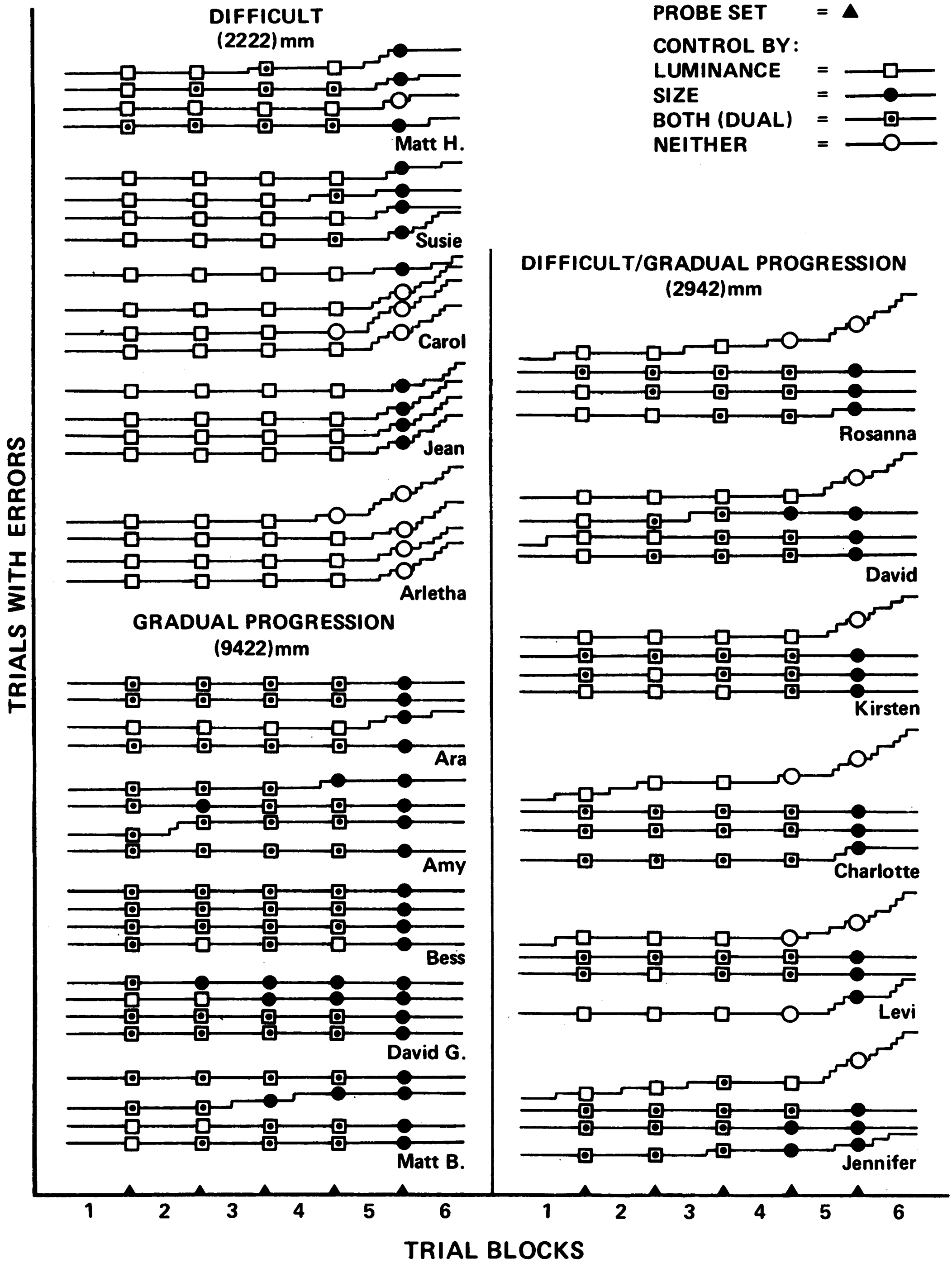

Figure 2. Performance of sixteen children given four sessions of successive circle-size discrimination problems. For each child, Session One is the top data line. Each problem had a 50-trial fading series on luminance (Blocks 1-5), a 10-trial criterion (Block 6), and 5 probe sets (indicated by filled triangles on the abscissa). Each trial moves the data line one unit to the right; each errorful trial moves the line one step upward. Each child received one of three conditions. The Difficult Condition, indicated by (2222)mm, presented four sessions on the "Difficult" discrimination (2 mm difference between S+ and S–). The Gradual Progression Condition, (9422)mm, presented size discrimination problems in the sequence: 9 mm, 4 mm, 2 mm, 2 mm. In the Difficult/Gradual Progression Condition, (2942)mm, the sequence was 2 mm, 9 mm, 4 mm, and 2 mm.

was removed in the fifth trial block, errors occurred: subjects responded on nearly all S+ and S− trials. Probe data demonstrated a general lack of control by the target feature—size—with only Carol showing control by size on a single probe set in the first session when the luminance cue was no longer available. On the criterion trials of the first session, she made two errors. On her next three sessions of the difficult problem, however, there was no indication of control by size on criterion trials or on probes. None of the probes for Carol, Jean, or Arletha revealed dual control by luminance and size.

The other two subjects in this group, Matt H. and Susie, acquired limited and unreliable control by size after errors were made, but this control did not persist in subsequent sessions. For Susie, even after errorless performance on criterion on the second and third sessions, responding on subsequent sessions began under exclusive control of luminance. Size control developed late in each session, only after errors occurred as luminance was completely faded in the fifth trial block. Matt H.'s errors decreased consistently from the first through the fourth session, but on each of the first three sessions, errors occurred in the fifth block as the luminance cue became more and more subtle. Unlike the probe data for the other four subjects, Matt's probe data did indicate extensive periods of dual control by luminance and size.

In general, for three of the five subjects given four sessions on the difficult problem, there was no indication of control of responding by size on any of the four sessions. Responding was nearly errorless and under the sole control of luminance until the luminance differences became very subtle. When luminance was eliminated, responding was no longer differential. The other two subjects in this group acquired limited and unreliable control by size after errors were made, but this control did not persist in subsequent sessions. In general, on each session, errors occurred as the luminance cue was removed.

Gradual progression condition. Data from these five subjects are shown in the lower left panel of Figure 2. This group received the easy problem and intermediate problem before two sessions on the difficult size discrimination problem. It was expected that they would learn the difficult size problem without errors because of their mastery of easier size discriminations. A comparison of each subject's performance on the third and fourth session with the performance of subjects in the Difficult Condition on the third and fourth session supports this expectation. Four of the five subjects in the Gradual Progression Condition performed errorlessly on all criterion trials of the difficult problem (2 mm difference); the fifth subject, Ara, made only one error on criterion in the third session.

In general, probe data showed dual control by luminance and size well before the luminance cue was completely faded on the easy, intermediate, and difficult size discriminations. Some individual differences in stimulus control were revealed by the probes. For example, on the easy problem (9 mm difference), three subjects showed dual control from the first through the fourth probe set (Ara, Bess, and Matt B.); one subject showed dual control through the third probe set (Amy); and one subject showed dual control only on the first probe set, and control by size alone on the following four probe sets (David G.). All subjects showed control by size alone on the fifth probe set and performed errorlessly on criterion for the two easier problems. On the first administration of the difficult problem, however, two subjects showed control by luminance alone (Ara and Matt B.). With Matt B., dual control emerged by the third probe set. Ara had some difficulty as the luminance cue was removed, indicated by two errors in the fifth trial block of the third session. The other three subjects showed dual control on the first four probe sets of the third session, followed by control by size alone on the fifth, criterion probe set.

Difficult/Gradual progression condition. Six subjects were given the most difficult problem as their first size discrimination problem, followed by a progression in problem difficulty in the sequence: easy, intermediate, and difficult. When the most difficult problem was presented first, the fading series uniformly failed to establish the size discrimination. As shown in the right side of Figure 2, the subjects performed reasonably well until quite near the end of the luminance fading series. Two of the subjects (Kirsten and David R.) made no errors in the first four blocks, the others made a few scattered errors early in the fading sequence. However, by the time the fading cue was eliminated or almost eliminated, all subjects showed a lack of control by the target feature. During Block 6 with criterion trials, four subjects responded on all five S− trials, and the remaining two responded on four of the five S− trials.

The probe technique revealed the type of stimulus control during what superficially appeared to be a successful fading sequence. While few errors were made, only one of the subjects showed dual control at any point in the first fading session, and that was a temporary dual control at the third probe set for Jennifer. With this single exception, the first three sets of probes all showed luminance control alone. On the fourth probe, the last one in which luminance remained as even a subtle cue, the subjects differed in whether they showed a continued reliance on luminance alone or whether they showed control by neither feature. And finally, in the fifth criterial probe, no control was demonstrated; subjects responded on both probes and on S+'s and S−'s alike.

In their second and third sessions when these subjects were given the fading series with the easy and intermediate size discriminations, their performance along the fading series was quite similar to the performance of the children in the Gradual Progression Condition. Dual control by both properties was shown quite early, usually by the first probe set in both of these problems. Occasionally, the early probes showed control by luminance alone (David R. and Rosanna), followed by dual control. By the fifth criterial probe set, all subjects were controlled by size alone, as luminance was no longer available as a cue. In two instances (David R. and Jennifer), size alone controlled during the fourth probe set when the luminance cue became more subtle.

When, on the fourth session, these subjects were again given the difficult discrimination (2 mm difference), luminance alone typically controlled responding according to the early probes, and dual control emerged at least before the fourth probe set. In one instance (Jennifer), control had shifted from dual control to control by size alone on the fourth probe set. Overall, the subjects in this group on their second exposure to the difficult problem made more errors than subjects on their first or second exposure in the Gradual Progression Condition. Two subjects, Kirsten and David R., performed perfectly on the criterion trials and on the preceding block when the luminance cue was quite subtle. These two subjects showed the characteristic performance of the earlier group; others made a few errors. Two made errors only in the fifth block of trials in the final stage of the luminance fading. The remaining two, Jennifer and Levi, showed errors in the fifth block and on the criterion trials as well, with Jennifer responding to two of the five S− trials. Levi's performance was characteristic of a nonlearner (cf. Arletha's data in the Difficult Condition). He responded errorlessly through almost all of the fading series, but the probes showed that he continued under the control of luminance alone until, on the fourth probe set, he showed control by neither feature. Shortly thereafter he began responding to S− both just before and just after the final criterion probe which, paradoxically, indicated size control.

For four of the six subjects, the fading series and the progression in difficulty in the size discrimination worked to establish more or less errorless learning. For a fifth subject, Jennifer, there was considerable evidence of control by the target feature, but that control was not completely reliable; and for the sixth, Levi, one would hesitate to claim successful control.

Overall, the performance of these subjects on the difficult discrimination given after the two easier discriminations compares somewhat unfavorably with the performance of subjects in the Gradual Progression Condition. The exposure on the first session to the difficult problem before the progressive series seemed to hinder, somewhat, performance on the fourth session despite intervening errorless performance on the easy and intermediate problems. That the easier problems did have a facilitating effect, however, is revealed when this group's performance is compared with that of subjects in the Difficult Condition who had no experimental history with easier size problems.

Multiple Errors on S− Trials

Multiple errors on S− trials were possible because S− was not terminated until a required number of seconds without a response had elapsed. (The duration of S− increased from 3 to 5 sec within each trial block.) In Figure 2, trials with errors were plotted without distinguishing between single-error and multiple-error S— trials to make visible common patterns of responding that plotting each error would obscure.

Table 2 presents, first, the total number of errors that occurred on each problem for each subject including both single-error and multiple-error trials; second, the number of multiple-error trials; and third, the mean number of multiple errors on multiple-error trials only. As can be seen in Table 2, some subjects never responded to S— and some subjects never responded more than once on any S— trial. Those subjects who did respond repeatedly during S— did so primarily in their first session. Levi and Arletha were the only subjects who showed extensive multiple errors. In the first session of the difficult problem as luminance was faded, Levi and Arletha responded twice on nearly each S— trial through the end of criterion.

In general, after the first session, multiple responses during S— occurred infrequently. The subjects who did not learn the target size discrimination and who thus continued to make errors as the luminance cue was removed did not persist in multiple responding during S—.

DISCUSSION

A successful fading sequence produces errorless responding throughout acquisition. In order to do this, the target feature must control responding before the fading cue is completely removed. In the present study, considering only the performance on S+ and S— trials, responding in successful and unsuccessful sequences was indistinguishable over the early part of all sequences. Performance on probes, however, revealed striking differences in the features which actually controlled errorless responding. Exclusive control by the fading cue was characteristic of unsuccessful series; dual control by both the fading cue and the target features was characteristic of successful series. In general, only those subjects who showed dual control on probe stimuli continued to respond errorlessly on target discrimination.

Table 2

Total number of errors, number of trials with multiple errors, and mean number of multiple errors for each size problem.

Subject	*Total number of errors*				*Number of trials with multiple errors*				*Mean number of multiple errors on multiple error trials*
	Problem (mm difference between S+ and S— diameters)				Problem (mm difference between S+ and S— diameters)				
	9	4	2_1	2_2	9	4	2_1	2_2	
David G.	0	0	0	0	0	0	0	0	—
Amy	1	0	2	0	0	0	0	0	—
Ara	0	0	4	0	0	0	1	0	2.00
Bess	0	0	0	0	0	0	0	0	—
Matt B.	0	2	0	0	0	0	0	0	—
	2_1	9	4	2_2	2_1	9	4	2_2	
Jennifer	13	0	0	4	1	0	0	0	2.00
Charlotte	12	0	0	2	0	0	0	0	—
Rosanna	15	0	0	1	2	0	0	0	2.00
David R.	7	1	1	0	0	0	0	0	—
Kirsten	9	0	0	0	2	0	0	0	2.00
Levi	16	0	0	7	6	0	0	1	2.14
	2_1	2_2	2_3	2_4	2_1	2_2	2_3	2_4	
Carol	3	12	10	8	0	3	0	0	2.33
Jean	5	8	7	7	0	1	0	0	2.00
Arletha	27	7	7	8	8	0	1	1	2.20
Susie	3	2	2	5	0	0	0	0	—
Matt H.	5	3	2	1	1	0	0	0	2.00

Several factors influenced dual control and thus the likelihood of successful fading. When the same fading sequence on luminance was used with size discriminations of varying difficulty, errorless learning was accomplished if the size differences were prominent, but not if the size differences were small. With the prominent size cue, dual control by luminance and size was usually indicated early; with the difficult size cue on the first session, luminance control continued until this cue was no longer available and thereafter errors were extensive. Errorless learning of this difficult discrimination was accomplished in later sessions if it had been preceded by easier discrimination tasks along the same dimension. The performance of subjects who began with the difficult problem before the gradual progression was somewhat inferior to the performance of those who began with the gradual progression, even though both groups performed errorlessly on the easy and intermediate problems. Sidman and Stoddard (1967) and Touchette (1968) also found that giving subjects an initial difficult task interfered with the subsequent acquisition and retention of the particular discrimination on which errors were made.

An important consequence of a history of errors is that not only is the appropriate behavior not learned, but also inappropriate behavior may become established. In this study the appropriate behavior required a careful observation of the size of the circles. With prominent differences in the stimuli on the target feature, subjects may be more likely to observe these differences, thereby increasing the likelihood of the target stimulus acquiring control. If these differences are gradually made more subtle, this observing behavior, once established, is likely to be maintained. Inappropriate behavior included responding to each circle without regard to its size. Such inappropriate behavior would be intermittently reinforced and, especially for these children who were already working on an intermittent schedule, it might be expected to persist on the particular discrimination once it was established.

Many instructional tasks begin with stimulus control already within the learner's repertoire and gradually change this control until the target stimulus control is established. For example, in lessons designed to teach beginning reading (Kjeldergaard, Frankenstein, & Glaser, 1969), graphemes were color-coded according to particular sounds to be produced. Color was the fading cue and letter shape was the target feature. Observation of the target feature may be facilitated if the effect of gradually withdrawing or fading the original cue is to make the target feature more prominent. The present study has shown that this effect is most likely if the target feature is not extremely subtle.

The transfer method of stimulus control is risky, however, because the desired precursory behavior (observing the target stimulus and responding to it) may never be established. In shoddy instructional materials, the private precursory behaviors that lead to errorless public behaviors may be considerably different from the behavior desired by the designer; yet a correct response leads to reinforcement no matter what private behavior preceded it. Nevertheless, the transfer of stimulus control method merits continued investigation and analysis to clarify further how control is acquired by the target stimulus property at the early stages of training.

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